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A Guide to the Prevention of Running Injuries

SUMMARY

In North America, estimates of recreational runners have grown from two million in 1970 to 30 million in 1979. In Canada increased interest in running has been sparked by Participaction. Habituation to running is attributed to a sense of wellbeing and increased energy levels, as well as the possibility of reducing the threat of cardiovascular disease. Musculoskeletal injury is common to runners and can be prevented by carefully planned training programs, proper selection of training surface, regular stretching and strength drills, the use of protective footwear and balancing of vulnerable biomechanical alignments with functional orthotics in shoes. (Can Fam Physician 26:543-548, 1980).

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PRIOR TO 1970, the distance runner conjured the image of a loner estranged from the mainstream of society, the individualist, the introvert and the ectomorph who epitomized the "loneliness of the long distance runner". Over the next ten years an explosive change occurred in society's perception of running. Estimates of the number of recreational runners have grown from two million in 1970 to 30 million in 1979.[1] The "bible" of the running crowd, *Runner's World* has increased its circulation from 3000 to 500,000 during the same period. In Canada alone, running is a major part of the fitness explosion which involves some 13 million people. This fact alone accounts for increasing requests by patients to family physicians for advice on the relevance of running in a fitness program and the prevention and management of running-induced injury.

Sociological Factors

As western society has progressed from an agricultural base to industrialization and now to a computer automated system, the association of physical activity with employment has been removed. Physical labor was a necessity to survival in an agrarian culture; today the privilege of sweating on the job is a rarity. As automation and computer dominance advance, the need for physical expression by the individual will increase. Recreational outlets for this appetite are likely to continue growing in importance.

The explosive nature of growth in fitness awareness was facilitated in Canada by the media manipulation stimulated by Participaction. In 1972 the Canadian public was spurred on by the comparison of the 60 year old Swede equalling the fitness of the 30 year old Canadian. The positive social image of "being fit" is supported by some $25 billion per year in North America for advertising, marketing and public relations by industry where physical activity is featured as "healthy".[2] This image making trend is stirring the population out of their armchairs, converting the passive spectator into the active participant. The ego centred "me" generation look to themselves for their heroes.

Psychological Factors

A significant number of people exposed to running become habitual runners. They continue to seek out the sense of enjoyment or wellbeing they feel associated with the physical act of running. Distance running of eight to 16 kilometers covered in an easy, relaxed manner is more likely to be habituating than shorter, more strenuous runs.

It has been speculated that the positive addiction of regular running may be associated with the release of endomorphic substances. Research on this speculation is lacking but it is commonly accepted that the runner unable to pursue this activity becomes restless, tense and irritable during this withdrawal. Awareness of this is an extremely important factor in treating an individual with a running induced injury. If running must be curtailed, specific instruction in substitution of swimming or cycling is essential.

Potential positive benefits to the

health profile of the regular runner involve cessation of smoking, decrease in body weight, reduction in alcohol use and increased stress tolerance.

Physiological Factors

Exercise training is thought to produce a variety of cardiovascular and metabolic adaptations. Myocardial oxygen demand is reduced and stroke volume increased. Increased coronary vessel diameter and collateral circulation is theorized. Free fatty acid mobilization is enhanced and chylomicron production is decreased. Both insulin and triglyceride production is reduced.[3]

The American College of Sports Medicine has issued a position statement on the recommended quantity and quality of exercise for developing and maintaining fitness in healthy adults.

1. Frequency of training:
   three to five days per week.
2. Intensity of training:
   60-90% of maximum heart rate reserve or 50-85% of maximum oxygen uptake.
3. Duration of training:
   15-60 minutes of continuous aerobic training. Duration depends on intensity of training.
4. Mode of activity:
   Any activity that uses large muscle groups that can be maintained continuously and is rhythmical and aerobic in nature, i.e. running, walking, swimming, skating, cycling, rowing and cross country skiing.

Most epidemiological studies support the concept that regular exercising is an ameliorating factor in coronary artery disease. No study has yet shown that exercise aggravates cardiovascular disease or hastens the development of clinical symptoms.

Fig. 1
Classification of injuries

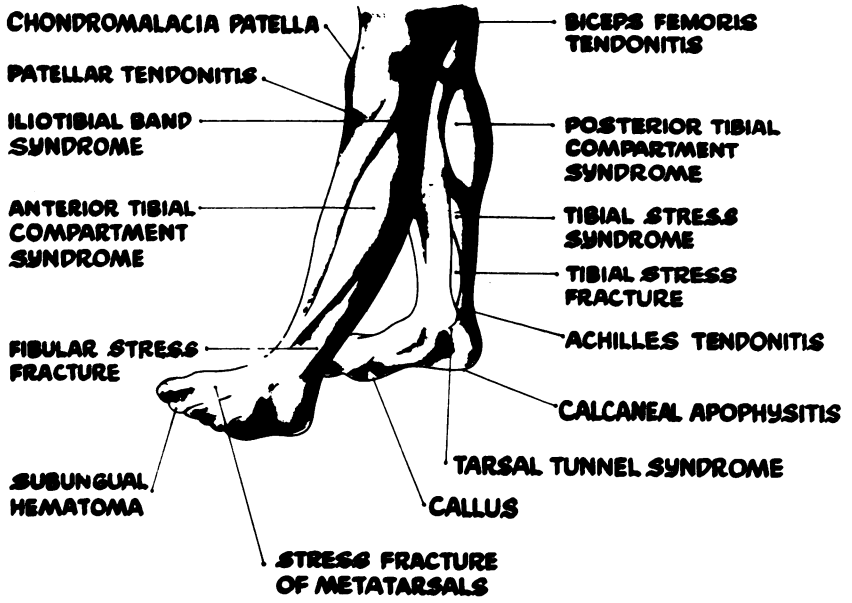
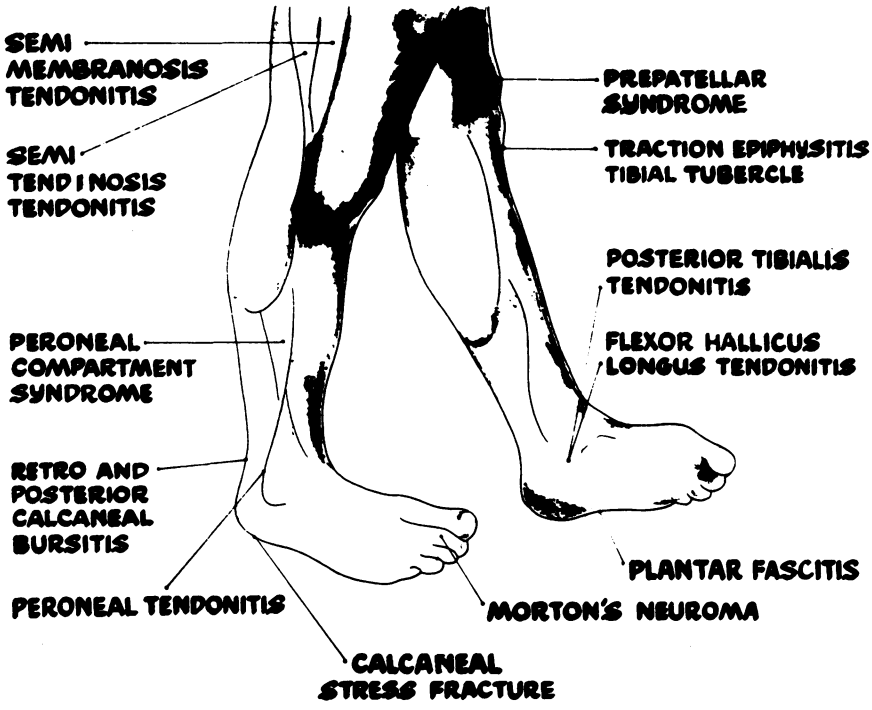


Fig. 2
Classification of injuries



Hazards of Running

The runner is exposed to some complications of exercise in the pursuit of a sense of wellbeing and good health. The most common complications involve the musculoskeletal structures of the lower extremities. These injuries generally involve microtrauma to muscle, tendon and bone which accumulates over repeated exposure to running. Usually insufficient muscle strength and endurance to meet the repeated demands of training converge with biomechanical vulnerability, to produce muscle and tendon partial rupture and stress reaction to bone. A partial classification of these stress injuries is outlined in Figures 1 and 2.

Although these injuries are devastating to the runner, they are seldom life threatening. It is important to recognize the hazard of heat injury in the runner, since this *can* be life threatening. When environmental temperature and humidity compromise body temperature regulation by interfering with skin evaporation and heat radiation, and dehydration complicates the matter, hyperthermia can strike the runner. Delirium, confusion and coma

can precede acute renal failure. This serious problem can be prevented by scheduling races early in the morning and educating runners in the necessity of drinking water regularly during long runs. The target pace should be slowed in warm weather and cancellation of races in hot humid weather may be necessary. Specific recommendations for fluid replacement and race scheduling have recently been made by the American College of Sports Medicine.[4]

Prevention

Fortunately serious complications of running are rare and the most common problem leading the runner to the doctor's office is the overuse injury. Prevention of these problems can be assisted by assessing the five major factors in etiology.[5]

1. Training methods
2. Training surfaces
3. Muscle dysfunction and inflexibility
4. Shoe design
5. Biomechanics of running

Training Methods

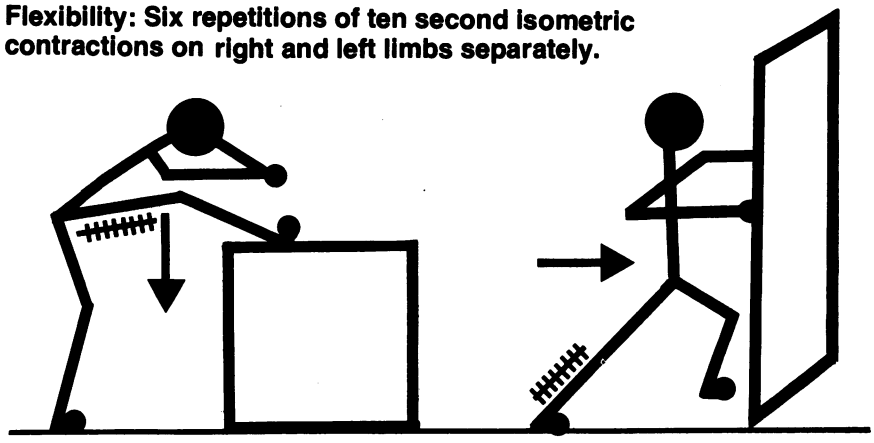
The most common cause of injury to runners is 'too much too soon'. James reports that more than 50% of running induced injuries in his study were caused by errors in training.[6] Excessive intensity and duration of running is commonly associated with a failure to allow physiological adaptation. Beginning runners are advised to run alternate days only and to adhere to the 'talk test'. The speed of running should be gentle enough that the subject can carry on a conversation with a running partner with no sense of breathlessness. This initial jog-walk program can generally be sustained for 20-40 minutes very early in an introductory program. As physiological adaptation occurs, the rate of running will automatically increase without awareness. An individual well conditioned for squash may find the specific muscle groups used in distance running more easily fatigued than predicted. Therefore prevention of injury can be achieved by initiating a program on alternate days at an easy pace. Finally an awareness of individual response to exercise is an important concept in prevention when group training is involved. Ideally, each person should individualize a training program. This will avoid the temptation to run at a rate best suited to the stronger individuals thus exposing the beginner to excess stress. The motto is 'train, don't strain'.

Training Surfaces

Most runners in Canada adapt to training on asphalt and concrete for many months of the year because of severe winter conditions. Generally this offers no problem if the transition from grass or trails is carried out gradually. Injury can occur when the habit-

Fig. 3
Flexibility and strength drills

Flexibility: Six repetitions of ten second isometric contractions on right and left limbs separately.



Strength: Three sets of 15 repetitions.

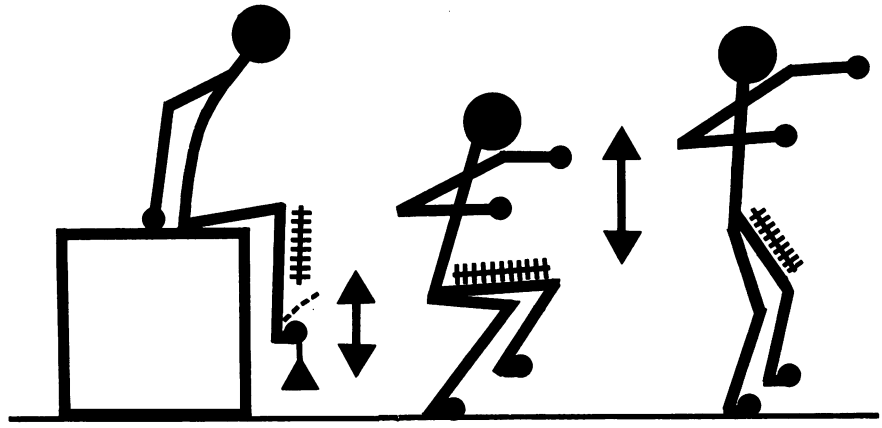
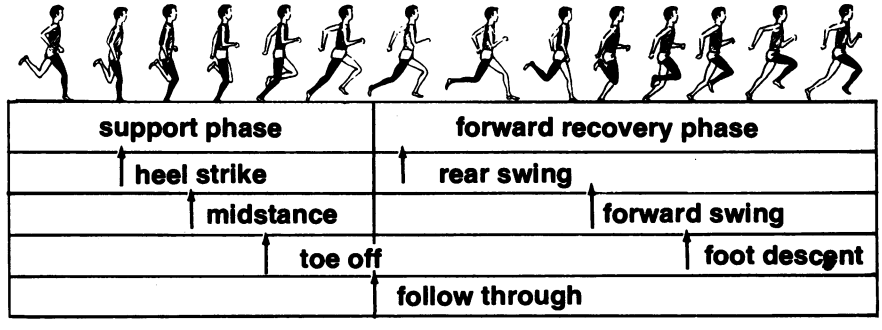


Fig. 4
Biomechanics of running



ual surface is abandoned and a new surface is suddenly introduced at the same training volume. This can occur either on soft bark mulch trails or concrete sidewalks, again demonstrating the specificity of training.

Muscle Dysfunction and Inflexibility

The microtrauma of overuse injury can lead to pain and limitation of movement. This can cause disuse atrophy and resultant muscle weakness. In the face of further overuse from running, pain is even more readily induced by increased microtrauma. Disuse atrophy increases and a cycle of reinforcement is initiated.[7]

This problem can be prevented by strength increasing exercises and flexibility drills at the first sign of overuse. Running strengthens the hamstring and the gastrocnemius muscles; consequently these groups require stretching. The quadriceps and the anterior tibial muscle groups are not stimulated as much in running and require additional strengthening drills. Figure 3 outlines minimal flexibility and strength drills that should be carried out by runners. The flexibility work should be done both before and after each running session. The strength work can be carried out three times a week on alternate days. The stretching should be done with a static hold using a sense of tension as a guide. Pain with

Fig. 5
Biomechanics of running

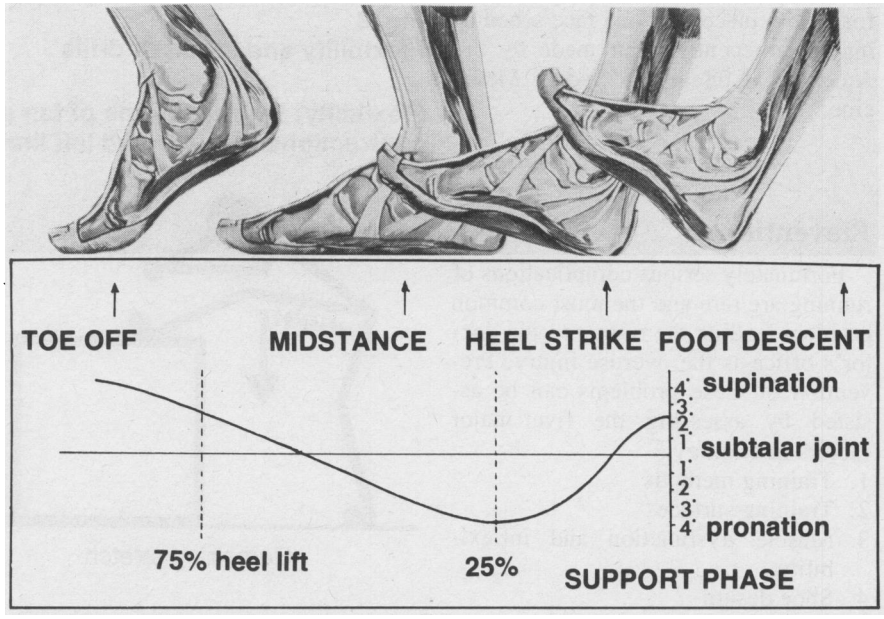
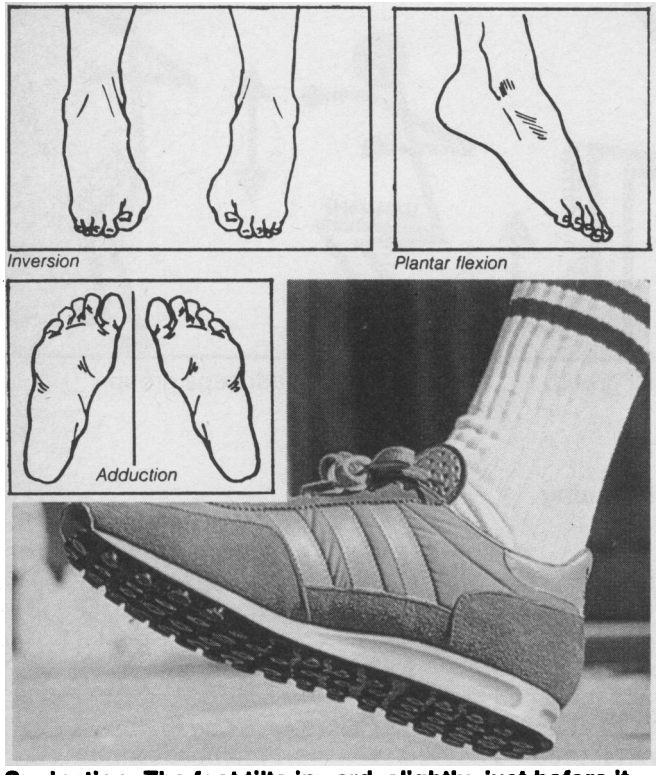
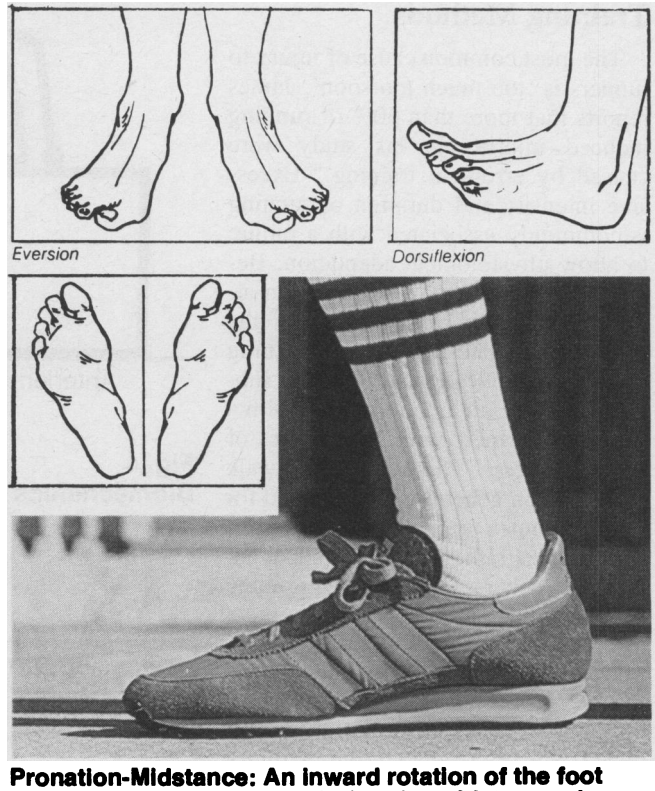


Fig. 6
Biomechanics of running



Supination: The foot tilts inward, slightly, just before it touches the ground.

Fig. 7
Biomechanics of running



Pronation-Midstance: An inward rotation of the foot occurring simultaneously during the midstance phase, when the whole weight of the body is on the centre of the foot.

stretching indicates an excess force and should be avoided.

Shoe Design

Current shoe technology has made important contributions to the prevention of injury from running. A roomy toe box and absence of prominent stitching can help avoid subungual hematomas, blisters and corns. The mid sole is important in providing shock absorption and flexibility. Waffle style outer sole can be effective in dampening torque force. Achilles tendon injury and gastrocnemius muscle strain can be prevented by an adequate heel wedge of 12-15 mm and a solid heel counter to stabilize the calcaneus. Heel counter cushions can be successful in reducing the incidence of retrocalcaneal bursitis (see Fig. 2)

Biomechanics of Running

Runners who have a variety of biomechanic variations in the alignment of the lower extremity are more vulnerable to injury. Genu varum, genu valgum, tibial torsion, pes planus and pes cavus are predisposing factors. Figure 4 shows one gait cycle divided into the support phase and the forward recovery phase. Figure 5 describes the support phase by showing foot descent, heel strike, midstance and toe off. The foot prepares for descent by assuming a supinated position. Following heel strike the foot pronates and reaches maximal pronation on midstance. During this time the foot has been a mobile adaptor and absorbed much of the shock of landing. Resupination starts in midstance. The foot becomes a rigid lever by the locking of the mid tarsal joint facilitating toe off.[8] Supination as shown in Figure 6 involves a complex movement of the ankle, subtalar and mid tarsal joints composed of plantar flexion, inversion and adduction. Pronation as shown in Figure 7 is composed of dorsiflexion, eversion and abduction.

Figure 8 shows the stress line of the support phase starting on the lateral corner of the heel, advancing to the base of the fifth metatarsal and moving medially to the first metatarsal for toe off. Figure 9 describes the biomechanically "ideal" foot in the neutral or unweighted position. This can be assessed in the runner by examining the alignment of the transverse planes of the rearfoot and forefoot in relation to the vertical axis of the leg in the prone position. The pes planus foot will often show a forefoot varus in the neutral position but when compensated during weightbearing will appear as a rearfoot valgus and a visually 'low arch'. The pes cavus foot will show a forefoot valgus when unweighted but when compensated during weightbearing will appear as a rearfoot varus and a visually 'high arch'. Figure 10 shows the forefoot varus foot with a medial forefoot post which can be achieved with a functional orthotic thus blocking the compensated position. This device prevents excess pronation which occurs because of the varus alignment. When combined with 1000 foot strikes per mile in running, excess pronation can produce:

1. Compression of the metatarsals causing Morton's neuroma
2. Torque of the metatarsal causing stress fracture

Fig. 8
Biomechanics of running

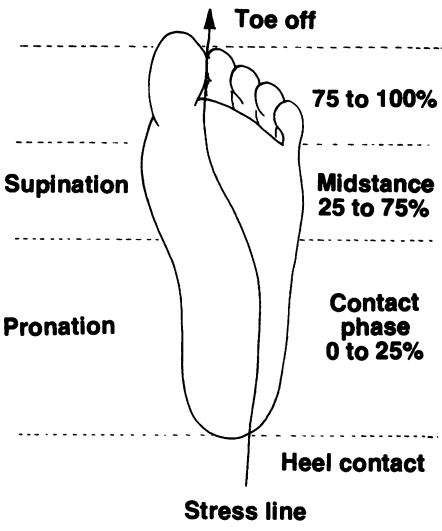


Fig. 9
Biomechanics of running

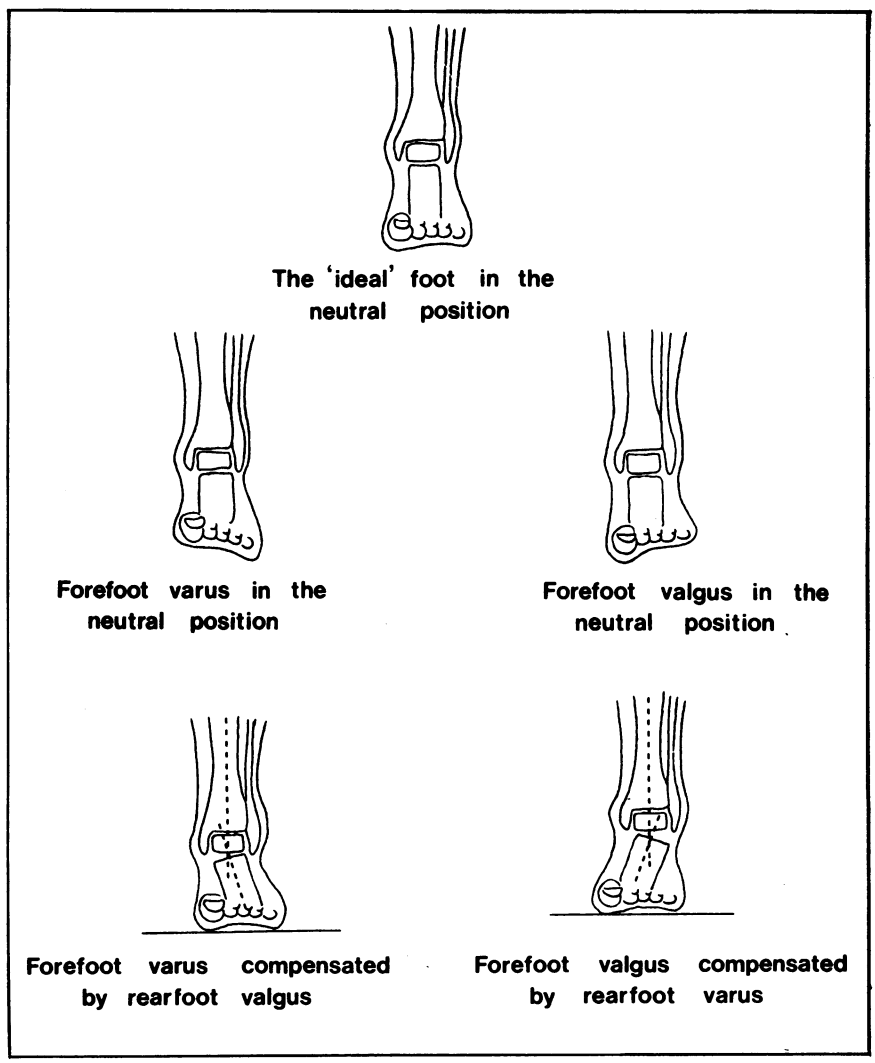
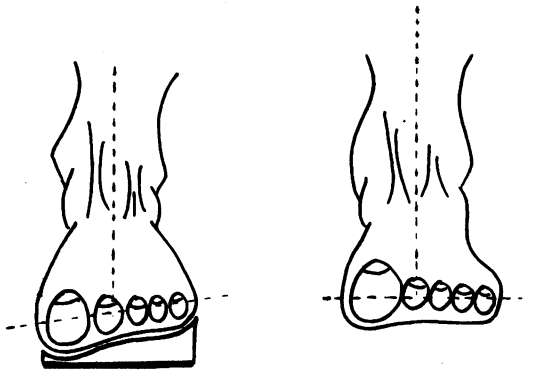


Fig. 10
Biomechanics of running

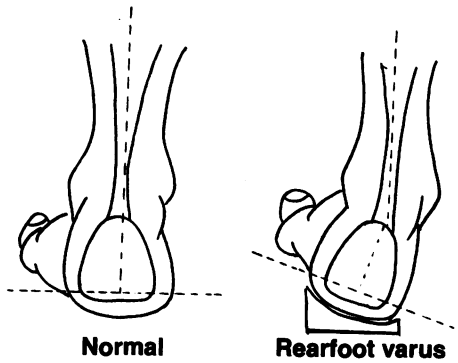


Forefoot valgus with lateral forefoot post

Normal alignment

Forefoot varus with medial forefoot post

Fig. 11
Biomechanics of running



Normal alignment

Rearfoot varus with medial heel post

3. Torque on the plantar fascia causing plantar fasciitis
4. Rearfoot valgus, which causes eccentric pull on the Achilles tendon, compression on peroneal tendons and stretching of the posterior tibialis tendon
5. Excess internal tibial rotation which causes tibial stress fractures, overuse knee and hip injury

Figure 11 shows a rearfoot varus foot with a rearfoot post on a functional orthotic.

In general runners with pes planus and other varus alignments will be aided in the prevention of recurring overuse injuries by the use of functional orthotics to control excess pronation, which can produce an increased rotational force in the foot and lower extremity.[9]

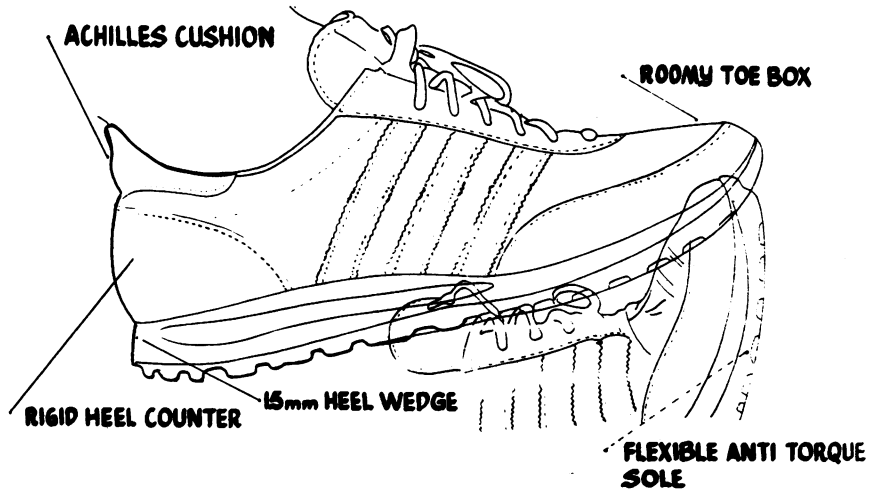
A varus wedge can be made from plastazote and ⅛ inch orthopedic felt, or a product like a Scholl's Runner's Wedge can be suggested. In more severe problems, plaster casts of the feet in the neutral position can be taken and semi rigid functional orthotics ordered from an orthotic laboratory to achieve a customized fit.[10]

In general, runners with pes cavus will suffer from a decreased ability to absorb shock because the normal pronation phase is shortened. Soft orthotics from plastazote to balance the foot or simply a Spenco insole to facilitate shock absorption inside the shoe will aid in preventing injury. The pes cavus foot will infrequently benefit from semi rigid functional orthotics.

Summary

Preventive programs to reduce running injury consist of:

Fig. 12
Prevention



1. Correcting training programs to allow for individual differences and physiological adaptation.
2. Selection of appropriate training surfaces and terrain.
3. Selection of training shoes with maximum protection (Fig. 12).
4. Lower extremity flexibility and strength programs.
5. Balancing of foot abnormalities with functional soft and semi rigid orthotics.

Conclusion

The reduction of injuries to runners—both competitive and recreational—can be achieved by awareness of the etiological factors when training and fitness programs are designed and by early recognition of the signs and symptoms of injury by both participant and medical advisor. ◉

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